(19) Europäisches Patentamt
Europ an Patent Office
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(11) EP 1 115 183 A1

(12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
11.07.2001 Bulletin 2001/28

(51) Int Cl.[7]: **H01R 13/646**, H01R 13/703

(21) Application number: **01400033.5**

(22) Date of filing: **08.01.2001**

(84) Designated Contracting States:
AT BE CH CY DE DK ES FI FR GB GR IE IT LI LU MC NL PT SE TR
Designated Extension States:
AL LT LV MK RO SI

(30) Priority: **07.01.2000 JP 2000001916**

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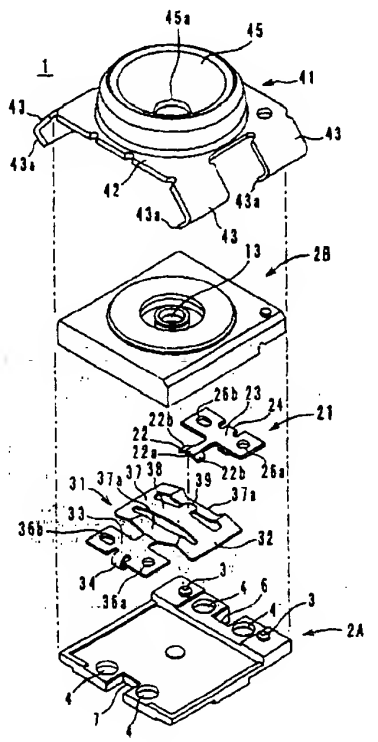
(54) Movable terminal, coaxial connector, and communications apparatus incorporating the same

(57) The present invention provides a movable terminal (31), a coaxial connector (1), which are durable and have good contact/connection reliability, and a communications apparatus incorporating the same. A coaxial connector (1) is formed by a two-part-split synthetic resin case having a lower insulating case (2A) and an upper insulating case (2B), a metal fixed terminal (21), a movable terminal (31), and an external terminal (41). The movable terminal (31) having a spring movable (resilient) function is composed of a movable contact portion (32) with which the fixed terminal (21) makes contact, a fixed portion (33) fit in the upper and lower insulating cases, and a lead portion (34) bent in an L-shape. The movable contact portion (32) has a frame portion (37), a spring movable (resilient) portion (38) upwardly curved in a circular form, and a contact portion (39) formed at the center of the spring movable portion (38).

FIG. 1



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Description

BACKGROUND OF THE INVENTION

1. Field of the Invention

[0001] The present invention relates to movable terminals, coaxial connectors, and communications apparatuses incorporating the same.

2. Description of the Related Art

[0002] Below, it is to be understood that the expression "spring" used in references to "springing properties", "spring movable functions", "spring supporting portions", and the like, does not refer limitatively to a mechanical spring but denotes, more generally, items having "springiness", "elasticity" or "resilience".

[0003] Conventionally, there are mobile communications apparatuses such as mobile phones, which incorporate surface-mounted-type coaxial connectors having signal-path switching functions. In such a coaxial connector, usually, a resin case, a fixed terminal, and a movable terminal having springing property are integrally insert-molded.

[0004] As shown in Fig. 12, a conventional movable terminal 155 includes a movable mechanical portion 151 having a spring movable function and a lead portion 152 bent in a U-shape connected to the movable mechanical portion 151. The movable mechanical portion 151 includes an arm 151a extending to right-and-left sides from the lead portion 152, two spring supporting portions 151b formed at the ends of the arm 151a, a spring movable portion 151c extending substantially parallel to the arms 151a in such a manner that the portion 151c straddles the spring supporting portions 151b, and a contact portion 151d protruding from the spring movable portion 151c. Both ends of the spring movable portion 151c are supported and fixed by the spring supporting portions 151b. The central part of the spring movable portion 151c is curved in a circular form so as to extend upwardly. With the force exerted by the springing property of the circular-formed springy mechanism, the contact portion 151d abuts with the lower surface of a contact part 141 of a fixed terminal 140, and thereby the fixed terminal 140 makes contact with the movable terminal 155 to be connected to each other.

[0005] However, the conventional movable terminal 155 has only one arm 151a and only two bent parts A and B. As a result, when the conventional movable terminal 155 is repeatedly pressed into contact with the central contact of the counterpart coaxial connector, plastic deformation of the movable terminal 155 occurs, thereby deteriorating the springing property. That is, after removing the counterpart coaxial connector, the fixed terminal 140 and the movable terminal 155 cannot be contacted and connected in a stable manner. In some cases, both terminals 140 and 155 can remain non-contact.

SUMMARY OF THE INVENTION

[0006] Accordingly, it is an object of the present invention to provide a movable terminal, a coaxial connector, which are durable and have good contact/connection reliability, and a communications apparatus incorporating the same.

[0007] In order to accomplish the above object, the present invention provides a movable terminal including a frame-shaped portion, a resilient movable portion having both ends supported by the frame-shaped portion and having a displaceable resilient central part, and a contact portion integrally formed with the resilient movable portion and adapted to make contact with a fixed terminal so that the contact portion is connected to the fixed terminal, in which two arms arranged in parallel to the resilient movable portion of the frame-shaped portion are bent such that the resilient movable portion is curved in a circular, or convexly-curved, shape.

[0008] Preferably, the contact portion is formed on the top of the resilient movable portion curved in the circular shape.

[0009] The present invention further provides a coaxial connector including an insulating case having a cavity in which the central contact of a counterpart coaxial connector is inserted, the movable terminal disposed in the cavity of the insulating case such that the movable terminal protrudes in a direction substantially perpendicular to a direction in which the central contact is inserted, a fixed terminal disposed in the cavity of the insulating case to make contact with a contact portion of the movable terminal so that the fixed terminal is connected to the contact portion, and an external terminal disposed on the outside of the insulating case to be electrically connected to an external conductor of the counterpart coaxial connector, in which the contact portion of the movable terminal and the fixed terminal separate from each other and make contact to be connected to each other in accordance with the installation and removal of the counterpart coaxial connector.

[0010] Since the frame-shaped portion has a high mechanical strength, the plastic deformation of the movable terminal hardly occurs even though the movable terminal is repeatedly pressed into contact with the central contact of the counterpart coaxial connector. As a result, the deterioration of springing property (elasticity) can be prevented. Moreover, the resilient movable portion is curved in the circular form by bending a flat plate instead of curving by plastic deformation. Thus, plastic deformation is more unlikely to occur.

[0011] In addition, the present invention provides a communications apparatus incorporating the above coaxial connector, thereby having high reliability.

BRIEF DESCRIPTION OF THE DRAWINGS

[0012] Further features and advantages of the present invention will become apparent from the following description of preferred embodiments thereof, given by way of example, and illustrated by the annexed drawings, in which:

Fig. 1 is an exploded perspective view showing an embodiment of a coaxial connector according to the present invention;
Fig. 2 is an enlarged perspective view of a movable terminal shown in Fig. 1;
Fig. 3 is a front view of the movable terminal shown in Fig. 2;
Fig. 4 is a right side-surface view of the movable terminal shown in Fig. 2;
Fig. 5 is a left side-surface view of the movable terminal shown in Fig. 2;
Fig. 6 is a perspective view showing the appearance of the coaxial connector shown in Fig. 1;
Fig. 7 is a sectional view of the coaxial connector shown in Fig. 6;
Fig. 8 is a schematic sectional view for illustrating the spring function (elasticity) of a resilient movable portion of the movable terminal;
Fig. 9 is a sectional view obtained when a counterpart coaxial connector is fitted in the coaxial connector shown in Fig. 6;
Fig. 10 is a schematic sectional view for illustrating the spring function (elasticity) of the resilient movable portion of the movable terminal in the above situation;
Fig. 11 is a block diagram of an embodiment of a communication apparatus according to the present invention; and
Fig. 12 is a perspective view showing a conventional movable terminal and a conventional fixed terminal.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0013] With reference to the attached drawings, a description will be given of a movable terminal, a coaxial connector, and a communications apparatus according to embodiments of the present invention.

[First embodiment: Figs. 1 to 10]

[0014] Fig. 1 is an exploded perspective view showing the structure of a coaxial connector according to an embodiment of the present invention. A coaxial connector (coaxial receptacle) 1 is composed of a synthetic resin insulating case split into a lower insulating case 2A and an upper insulating case 2B, a metal fixed terminal 21, a metal movable terminal 31, and a metal external terminal (an external conductor) 41.

[0015] The lower insulating case 2A has substantially a rectangular shape. At each of the two corners of one side of the upper surface (a split surface) of the lower insulating case 2A, a guide protrusion 3 for positioning the upper insulating case 2B is disposed. Near each of the guide protrusions 3, and on the opposite side of the lower insulating case 2A , cavity-like leg-receiving portions 4 for fitting the legs (not shown) of the upper insulating case 2B are provided. In addition, rectangular cut-away portions 6 and 7 are formed at the central parts of the mutually opposing edges of the lower insulating case 2A. The cut-away portion 6 contains a lead portion 24 (which will be described below) of the fixed terminal 21. The cut-away portion 7 contains a lead portion 34 (which will be described below) of the movable terminal 31. The dimensions of the cut-away portions 6 and 7 are set such that there is formed a clearance sufficient for preventing capillary effect due to the flux of solder used for mounting between the lower insulating case 2A and the lead portion 24 of the terminal 21 and the lead portion 34 of the terminal 31.

[0016] The upper insulating case 2B is substantially rectangular. An entrance hole 13 having a round cross section is formed in the center of the upper insulating case 2B. The entrance hole 13 penetrates the upper insulating case 2B. The central contact of a counterpart coaxial connector is supposed to be inserted into the entrance hole 13.

[0017] In addition, four round legs are disposed on the bottom surface (the other split surface) of the upper insulating case 2B. These legs are not shown in the figure. A groove 15 (see Fig. 7) having a V-shaped cross section is formed between the entrance hole 13 and an edge on which the fixed terminal 21 is led out. The groove 15 extends in a direction substantially perpendicular to the direction in which the fixed terminal 21 is led out.

[0018] Even though there is clearance arranged between the lower insulating case 2A and the lead portion 24 of the terminal 21 and the lead portion 34 of the terminal 31, when solder used for mounting is excessively applied, thereby exceeding a prescribed amount, a solder flux enters from spaces between the insulating cases 2A and 2B and the terminals 21 and 31. Thus, the groove 15 crossing with the fixed terminal 21 is disposed on the split surface of the upper insulating case 2B. With this groove 15, there is provided clearance for preventing capillary effect occurring between the insulating cases 2A and 2B and the fixed terminal 21. As a result, the flux cannot enter.

[0019] The fixed terminal 21 is typically formed by punching and bending a metal plate such as a flat stainless steel plate. The fixed terminal 21 is composed of a contact portion 22 with which the movable terminal 31 comes into contact, a fixed portion 23 sandwiched by the insulating cases 2A and 2B, and a lead portion 24 bent in an L-shape. Both sides of the contact portion 22 are folded at predetermined angles to form a horizontal

face 22a and inclined faces 22b on each side of the horizontal face 22a.

[0020] At the sides of the fixed portion 23 are formed a round hole 26a and an oval hole 26b. The legs of the upper insulating case 2B are fitted into the holes 26a and 26b, and the fixed terminal 21 is attached with the upper insulating case 2B with good positional accuracy with reference to the round hole 26a. The hole 26b has an oval shape in order to allow for production margin errors. The fixed terminal 21 is attached such that the horizontal face 22a of the contact portion 22 and the fixed portion 23 are in close contact with the bottom of the upper insulating case 2B. In addition, a clearance is provided at a part where the fixed terminal 21 crosses with the groove 15.

[0021] The lead portion 24 is downwardly extended substantially in parallel to a side surface of the lower insulating case 2A. The top end of the lead portion 24 is inwardly bent at an angle of substantially 90 degrees so that the top portion is flush with the bottom surface of the lower insulating case 2A. The lead portion 24 serves as a soldered part.

[0022] The movable terminal 31 is typically formed by punching and bending a metal plate such as a stainless steel plate having springing property in a predetermined shape. As shown in Figs. 2 to 5, the movable terminal 31 is composed of a movable contact portion 32 having a spring movable function and serves as a contact point with the fixed terminal 21, a fixed portion 33 attached in the insulating cases 2A and 2B, and a lead portion 34 bent in an L-shape. The movable contact portion 32 includes a frame-shaped portion 37, a spring movable (resilient) portion 38 whose both ends are supported by the frame-shaped portion 37, and a contact portion 39 disposed at the center of the spring movable portion 38.

[0023] The structure of the substantially rectangular frame-shaped portion 37 has a high mechanical strength, and plastic deformation thereby hardly occurs. Specifically, the frame-shaped portion 37 is composed of two spring supporting portions 37b connecting to the spring movable portion 38 and extending in a direction substantially perpendicular to the spring movable portion 38, and two arms 37a arranged substantially parallel to the spring movable portion 38. The spring movable portion 38 curves such that the portion 38 bulges upwardly in a circular shape, and has a desirable height at the top thereof. The contact portion 39 is provided on the top of the spring movable portion 38 curved in the circular shape.

[0024] The curve of the spring movable portion 38 is formed by folding the two arms 37a at four positions A, B, C, and D so that the centers of the two arms 37a downwardly bulge. Thus, the spring movable portion 38 maintains the curve obtained by bending a flat plate without using a curve due to plastic deformation. As a result, when the counterpart coaxial connector is installed and displaced, the spring movable portion 38 only reverses to be back to an initial flat configuration. Therefore, even though attachment and detachment of the counterpart coaxial connector are repeated, the plastic deformation of the spring movable portion 38 is more unlikely to occur.

[0025] At the sides of the fixed portion 33 are formed a round hole 36a and an oval hole 36b. Into the holes 36a and 36b are fitted the legs of the upper insulating case 2B, and the movable terminal 31 is attached to the upper insulating case 2B with accurate position. In this case, the movable terminal 31 is attached in a state in which the fixed portion 33 is closely attached to the bottom of the upper insulating case 2B.

[0026] The lead portion 34 is downwardly extended substantially in parallel to a side of the lower insulating case 2A. The top end of the lead portion 34 is inwardly bent at an angle of substantially 90 degrees so that the top end thereof is flush with the bottom of the lower insulating case 2A to be used as a soldered part.

[0027] The external terminal 41 in contact with the external conductor of the counterpart coaxial connector is typically formed by punching, bending, and drawing a plate of metal such as brass and spring phosphor bronze. A flat portion 42 of the center of the plate is disposed over the upper surface of the upper insulating case 2B. A leg 43 is disposed at each of the four corners of the flat portion 42. The legs 43 are folded along the side surfaces and bottom surface of an assembly composed of the terminals 21 and 31 and the insulating cases 2A and 2B. With this arrangement, the assembly has a hard structure. In addition, top end portions 43a of the legs 43 are arranged so that the portions 43a are substantially flush with the bottom of the lower insulating case 2A, and are used as soldered parts.

[0028] At the center of the flat portion 42, a through-hole cavity 45 is formed in such a manner that the through-hole cavity 45 is concentric with the round entrance hole 13 of the upper insulating case 2B. The through-hole cavity 45 has a conical opening, and a round hole 45a is formed at the center thereof. The external conductor of the counterpart coaxial connector is fitted into the through-hole cavity 45. The external terminal 41 is usually used as a ground. The external surface of the external terminal 41 is plated when necessary.

[0029] Fig. 6 shows a perspective view of the appearance of a coaxial connector 1 assembled in the above manner. Fig. 7 shows a sectional view thereof. As shown in Fig. 7, in the coaxial connector 1, since the top end portions of the terminals 21, 31, and 41 are formed substantially flush with the bottom of the lower insulating case 2A, they thereby form a surface-mountable structure. In addition, the through-hole cavity 45 is formed in the external terminal 41, a stable and reliable connection is achieved with the counterpart coaxial connector.

[0030] The fixed terminal 21 and the movable terminal 31 are arranged in such a manner that the fixed terminal 21 is disposed above the movable terminal 31 in the inside space of an insulating-case structure composed of

the insulating cases 2A and 2B. The movable contact portion 32 of the movable terminal 31 is arranged substantially horizontally in the inside space of the insulating-case structure. That is, the movable contact portion 32 is arranged in a direction substantially perpendicular to a direction in which the central contact of the counterpart coaxial connector is inserted.

[0031] Next, the function of the coaxial connector 1 will be illustrated with reference to Figs. 7 to 10.

[0032] As shown in Figs. 7 and 8, when the counterpart coaxial connector is not attached, the central part of the spring movable portion 38 curves upwardly. In this state, the movable terminal 31 is in contact with the fixed terminal 21 by the urging force due to the springing property of the spring movable portion 38, and both terminals 21 and 31 are electrically connected to each other.

[0033] In contrast, as shown in Figs. 9 and 10, when the counterpart coaxial connector is attached, the central part of the spring movable portion 38 is pressed down to be reversed by the central contact 65 of the counterpart coaxial connector inserted from the upper entrance hole 13, and the central part thereof extends downwardly in a circular form. In this situation, the contact portion 39 of the movable terminal 31 separates from the contact portion 22 of the fixed terminal 21 and thereby the fixed terminal 21 and the movable terminal 31 are electrically disconnected, while the central contact 65 and the movable terminal 31 are electrically connected. At the same time, the external conductor (not shown) of the counterpart coaxial connector is fitted into the external terminal 41 to be electrically connected to each other.

[0034] In the above situation, a reactive force occurs on both ends of the spring movable portion 38 (see Fig. 10). The reactive force is supported by the frame portion 37, particularly, by the folded parts A, B, C, and D formed on the two arms 37a. That is, as compared with the conventional movable terminal having only two folded parts shown in Fig. 12, the movable terminal 31 of the first embodiment has the four folded parts A, B, C, and D. As a result, the share load of the reactive force applied to each of the folded parts can be reduced. Thus, even though the movable terminal 31 is repeatedly pressed in contact with the central contact 65 of the counterpart coaxial connector and such a contact is continuously repeated for a long time, the plastic deformation of the movable terminal 31 hardly occurs and thereby the springing property of the movable terminal 31 is not deteriorated.

[0035] Furthermore, even if an excessive force is applied to the spring movable portion 38 when the counterpart coaxial connector is attached, since the lowest part of the spring movable portion 38 comes in contact with the upper surface of the lower insulating case 2A, the displacement of the spring movable portion 38 does not exceed a prescribed amount.

[0036] When the counterpart coaxial connector is removed from the coaxial connector 1, the central part of the spring movable portion 38 returns to an upwardly bulged state by using the springing property. In this state, the fixed terminal 21 and the movable terminal 31 are electrically connected to each other, while the central contact 65 and the movable terminal 31 are electrically disconnected from each other.

[Second Embodiment: Fig. 11]

[0037] A description will be given of a communications apparatus according to a second embodiment of the present invention by using an example of a mobile phone.

[0038] Fig. 11 shows an electric-circuit block diagram of an RF circuit of a mobile phone 120. In Fig. 11, reference numeral 122 denotes an antenna element, reference numeral 123 denotes a duplexer, reference numeral 125 denotes a selector switch, reference numeral 131 denotes a transmission-side isolator, reference numeral 132 denotes a transmission-side amplifier, reference numeral 133 denotes transmission-side interstage band pass filter, reference numeral 134 denotes a transmission-side mixer, reference numeral 135 denotes a reception-side amplifier, reference numeral 136 denotes a reception-side interstage band pass filter, reference numeral 137 denotes a reception-side mixer, reference numeral 138 denotes a voltage-controlled oscillator (VCO), and reference numeral 139 denotes a local band pass filter.

[0039] In this case, as the selector switch 125, the coaxial connector 1 in accordance with the first embodiment can be used. With this arrangement, for example, when the electrical characteristics of the RF circuit are checked in a process for manufacturing the mobile phone 120, by fitting a measurement probe (the counterpart coaxial connector) 126 connected to a measuring apparatus into the coaxial connector 1, a signal path from the RF circuit to the antenna element 122 can be switched to a signal path from the RF circuit to the measuring apparatus. When the measurement probe 126 is removed from the coaxial connector 1, the signal path from the RF circuit to the measuring apparatus is again switched to the signal path from the RF circuit to the antenna element 122. With the installation of the coaxial connector 1, the mobile phone 120 can obtain high reliability.

[Other embodiments]

[0040] The movable terminal, the coaxial connector, and the communications apparatus in accordance with the present invention are not restricted to the above embodiments. Various modifications and changes can be made without departing from the scope of the invention as defined in the claims.

[0041] In the above embodiments, the coaxial connector is formed by separately producing terminals and insulating cases to combine both of them. However, the

coaxial connector may be formed by integrally insert-molding the terminals in the insulating cases. In addition, the outline of the insulating cases and the configuration of the cavity may be arbitrarily selected according to specifications. For example, they may have rectangular or round forms.

[0042] Furthermore, terminals used in the invention are not restricted to surface-mounted type terminals. The terminals of insert-mounted type may be used. In addition, after separately producing the movable contact portion of the movable terminal, the fixed portion, and the lead portion, these components may be connected to each other by wielding.

[0043] As described above, in the present invention, the movable terminal includes the frame-shaped portion. The two arms of the frame-shaped portion are bent and the spring movable portion is curved in a circular form. As a result, the plastic deformation of the movable terminal hardly occurs, and the springing property of the movable terminal is not deteriorated. Thus, the coaxial connector and the communications apparatus having high reliability can be obtained.

Claims

1. A movable terminal (31) comprising:

   a frame-shaped portion (37);
   a resilient movable portion (38) having both ends supported by the frame-shaped portion (37) and having a displaceable resilient central part; and
   a contact portion (39) integrally provided with the resilient movable portion (38) and adapted to make contact with a fixed terminal so that the contact portion is connected to the fixed terminal;
   wherein two arms (37a) of the frame-shaped portion (37), arranged substantially parallel to the resilient movable portion (38), are bent such that the resilient movable portion (38) is curved in a circular form.

2. A movable terminal (31) according to Claim 1, wherein the contact portion (39) is formed on the top of the resilient movable portion (38) curved in the circular form.

3. A coaxial connector (1) comprising:

   an insulating case (2A,2B) having a cavity in which the central contact of a counterpart coaxial connector is inserted;
   the movable terminal (31) according to one of Claims 1 and 2, disposed in the cavity of the insulating case such that the movable terminal (31) protrudes in a direction substantially perpendicular to a direction in which the central contact is inserted;
   a fixed terminal (21) disposed in the cavity of the insulating case to make contact with the contact portion (39) of the movable terminal (31) so that the fixed terminal (21) is connected to the contact portion (39); and
   an external terminal (41) disposed on the outside of the insulating case to be electrically connected to an external conductor of the counterpart coaxial connector;
   wherein the contact portion (39) of the movable terminal (31) and the fixed terminal (21) separate from each other and make contact to be connected to each other in accordance with the installation and removal of the counterpart coaxial connector.

4. A communications apparatus incorporating the coaxial connector (1) according to Claim 3.

FIG. 1

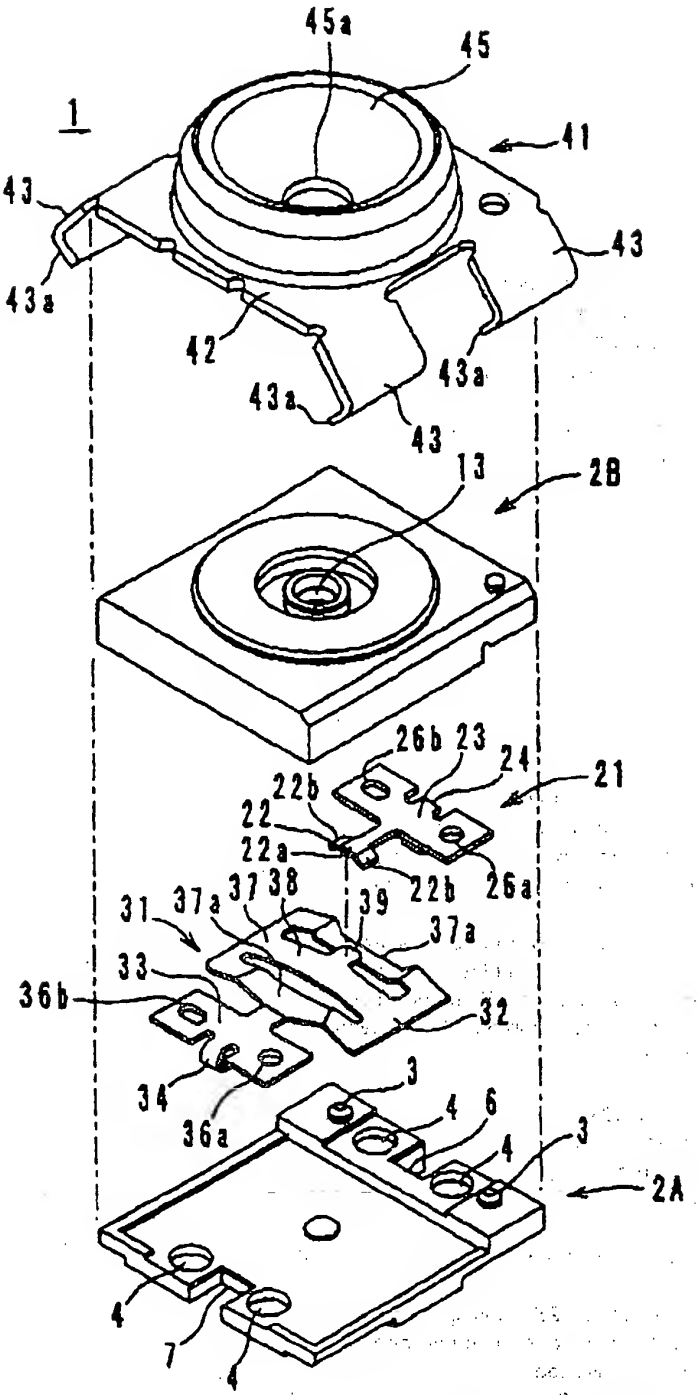


FIG. 2

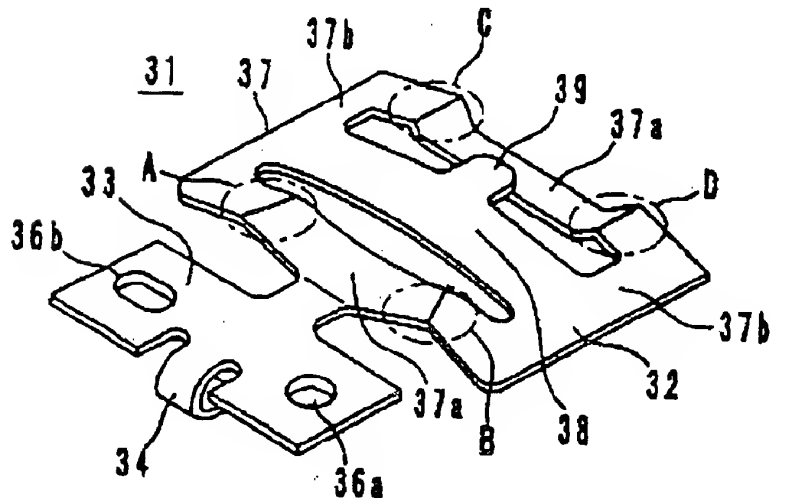


FIG. 3

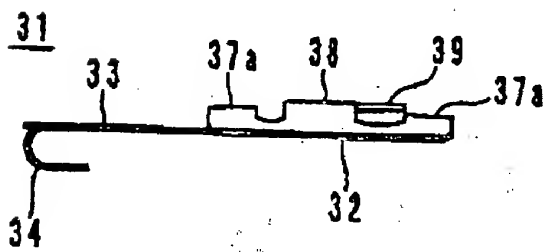


FIG. 4

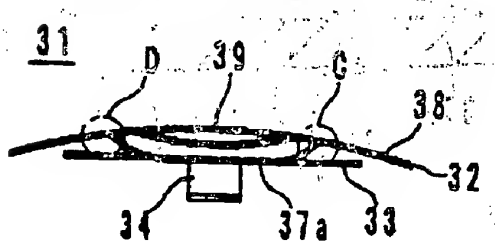


FIG. 5

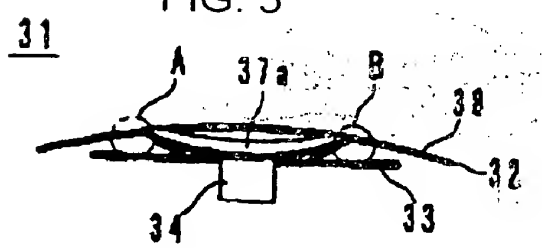


FIG. 6

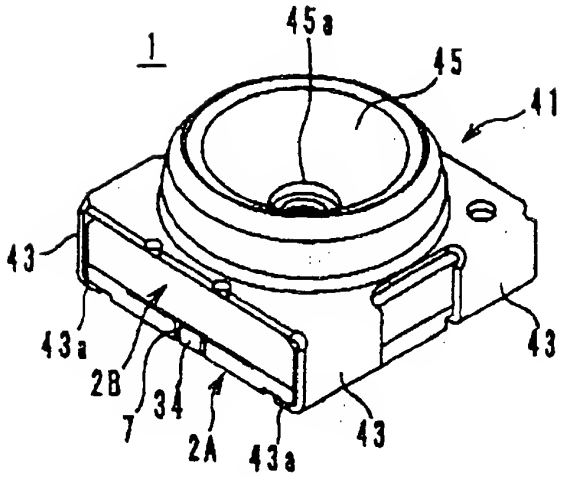


FIG. 7

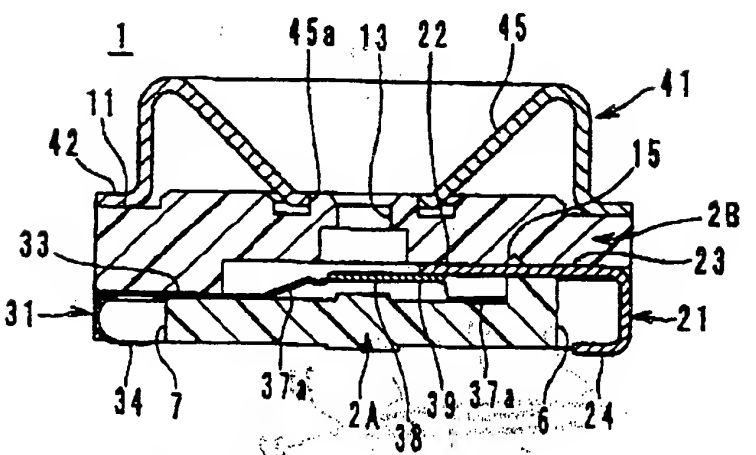


FIG. 8

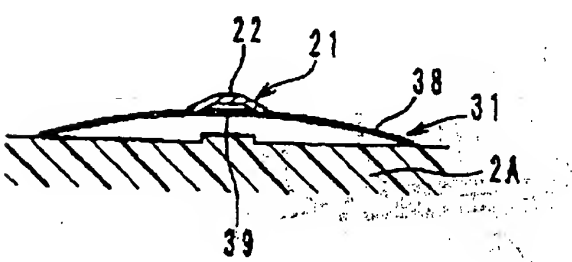


FIG. 9

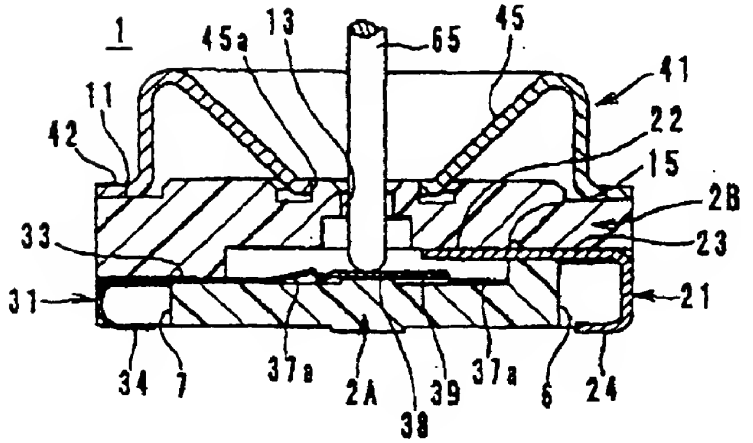


FIG. 10

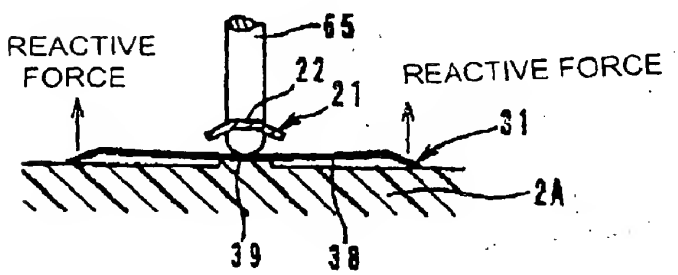


FIG. 11

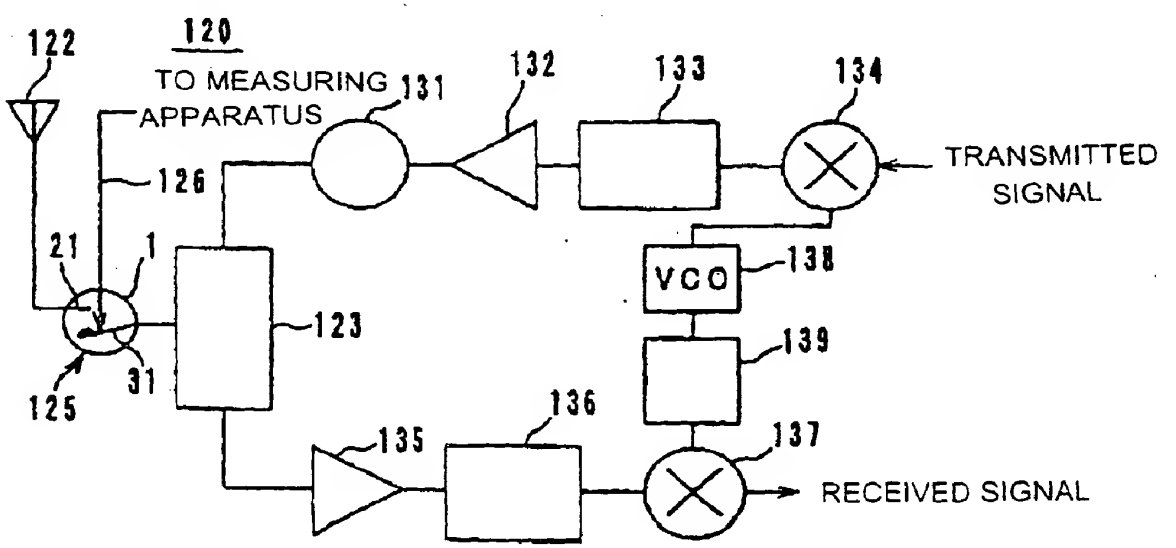
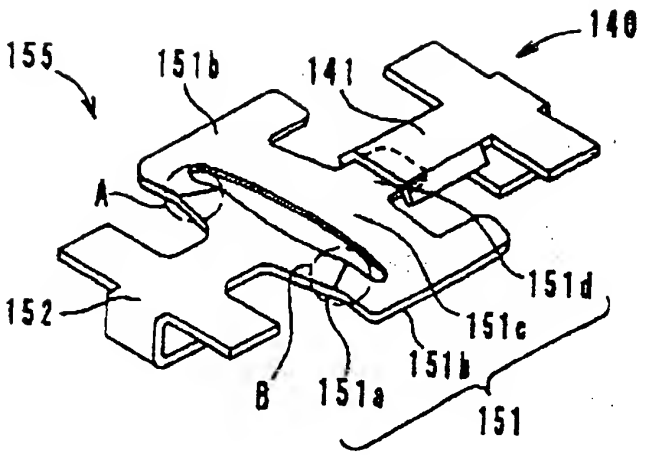


FIG. 12



European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 01 40 0033

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.7)
A	EP 0 929 128 A (MURATA) 14 July 1999 (1999-07-14) * column 6, line 11 - column 7, line 19; figures 1,2,7,9 *	1-4	H01R13/646 H01R13/703
A	WO 95 30258 A (POLAROID) 9 November 1995 (1995-11-09) * page 19, line 10 - page 21, line 16; figures 7-9 *	1	

TECHNICAL FIELDS SEARCHED (Int.Cl.7)

H01R

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
BERLIN	28 March 2001	Alexatos, G

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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A : technological background
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E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

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EPO FORM 1503 03.82 (P04C01)

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 01 40 0033

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
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28-03-2001

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